RECOVERY OF ALL THE FACULTIES IN A PIGEON FROM WHICH FOUR-FIFTHS OF THE UPPER PORTION OF THE CEREBRUM HAD BEEN REMOVED.

By J. H. McQuillen, M.D.

Monday, February 4th, 1878, in illustration of my regular course of lectures on Physiology in the Philadelphia Dental College, I exposed the cerebrum of a pigeon, as I have regularly done each session for the past twenty years, and cut out four-fifths of the upper portion in slices, to illustrate the fact that the sensorium thus exposed could be cut, pinched, or burned without any manifestation of suffering on the part of the animal. The usual phenomena attendant upon the operation followed, *i. e.*, profound stupor, the bird standing motionless on the table, with eyes closed, the head sunk between the shoulders, and the feathers ruffled. When pushed it opened its eyes and moved the body, when thrown into the air it flew a few feet, and then on lighting relapsed into somnolency with an evident obliviousness to surrounding objects until again aroused by handling. In this condition, along with another pigeon from which the cerebellum had been removed, it was shown to the members of the Biological and Microscopical Section of the Academy of Natural Sciences, on the evening of that day at the regular monthly meeting of the Section. Prof. Emily White, M.D., Professor of Physiology in the Woman's Medical College, who was present, having manifested much interest in the pigeons, I offered to send them to the Woman's College so that she could show them to the students, with the request that an effort should be made to keep them alive, and ascertain whether the functions of the cerebrum and cerebellum would be restored. Other duties of an absorbing character so occupied my time and attention that I had quite forgotten the request made by me until March, when a note was received from Prof. White stating that "the pigeon from which the cerebrum was partially removed seems to have recovered all his faculties. He is, perhaps, less excitable than normal, seems perfectly tame, but bright. . . . The other pigeon died on the third day after the removal of the cerebellum."

I at once sent for the pigeon, and was surprised at the complete recovery of the voluntary movements of walking and flying, the

power of feeding itself and drinking as usual, and the general manifestation of intelligence. There could be no question about the identity of the pigeon. It was of a peculiar breed, and the cicatrix on the neck, where the incision had been made so as to throw the scalp back and expose the cranium, along with a soft place on the latter from which a portion of bone had been removed, left no doubt on that point. I again exhibited it at the monthly meeting of the Biological and Microscopical Section, March 4th, and the members were surprised to find it fly about from one end of a long room and back again, feed itself, etc.

I asked then, and I repeat now the same question, How are we to account for the restoration of these functions? Is it due to the fact that the small portion of the cerebrum left after the operation assumed the functions of the entire organ, or has there been a regeneration of the part removed? Vulpian, one of the most accurate and reliable of the recent experimentalists and observers of these phenomena, positively asserts that an animal from which the cerebral hemispheres have been removed, is incapable of a spontaneous voluntary movement. In this he is apparently supported by every observer, with only one exception, Voit.

The latest author, in writing on this subject, M. Foster[1] (whose views may be regarded as summing those generally entertained), says: When the cerebral hemispheres are removed from a bird the animal is able to maintain a completely normal posture, and that too when the corpus striata and optic thalami are taken away at the same time. It will balance itself on one leg, after the fashion of a bird which in a natural way has gone to sleep. In fact the appearance and behavior of a bird which has been deprived of its cerebral hemispheres are strikingly similar to those of a bird sleepy and stupid. Left alone in perfect quiet, it will remain impassive and motionless for a long time, it may be for an almost indefinite time. When stirred it moves, and then on being left alone returns to a natural easy position. Placed on its side or on its back it will regain its feet; thrown into the air it flies with considerable precision for some distance before it returns to rest. It frequently tucks its head under its wings, and if by judicious feeding it has been kept alive for some time after the operation, it may be seen to clean its feathers, and to pick up corn

[1] A Text Book of Physiology, by M. Foster, M.A., M.D., F.R.S. London, MacMillan & Co., 1878.

or drink water presented to its beak.[1] It may be induced to move not only by ordinary stimuli applied to the skin, but also by sudden sharp sounds, or flashes of light; and it is evident that its movements are, to a certain extent, guided by visual sensations, for in its flight it will, though imperfectly, avoid obstacles. Save that all signs of volition are absent, that the movements are on the whole clumsy, resembling rather those of a stupid, drowsy bird than those of one quite wide awake, there is very little to distinguish such a bird from one in full possession of its cerebral hemispheres.

There is but one other case on record that I have met with, where there has been a recovery of voluntary action on the part of a pigeon from which the cerebral hemispheres had been removed, and I was not aware of that fact until the experience with my pigeon induced me to make a careful examination of the literature of the subject. I refer to the pigeon kept alive by Voit for five months after the cerebral lobes had been completely removed. "At first the pigeon presented the phenomena usually observed after this operation; but it gradually recovered, until it seemed entirely normal, with the single exception that it never would eat, all food being introduced forcibly. Five months after the operation the pigeon was killed, and the encephalic cavity was found filled with a white substance containing dark-bordered nerve-fibres and nerve-cells. Voit never before observed anything like regeneration of the nervous substance or so complete a restoration of the cerebral functions, and he regarded this as an instance of anatomical and physiological regeneration of the hemispheres." Flint,[2] from whom this extract has been taken, goes on to say that "the objections to accepting this observation, with the physiological conclusions presented by Voit, are that it is not only possible, but probable, that the hemispheres were not entirely removed, and that the posterior portion of the encephalon had advanced to occupy in part the space originally filled by the extirpated mass. While we do not assume that anatomical and functional regeneration of the cerebrum in a pigeon is impossible, it must be admitted that such an extraordinary state-

[1] Bischoff and Voit, Sitzungsberichte Acad. Wiss. München, 1863, pp. 479, 469, 1868, p. 105.

[2] Human Physiology, by Austin Flint, Jr., M. D. N. Y., D. Appleton & Co., 1876, p. 699.

ment as that made by Voit cannot be accepted without reserve, merely upon the basis of a single observation."

In contrast to this case it must be remembered that I only removed the upper four-fifths of the cerebrum. In doing this, however, the superficial gray matter of the hemispheres, recognized as the structure physiologically concerned in the exercise of the faculties of attention, perception, memory, and will, was removed.

The subject of the present communication continued in the full possession of its faculties for six months, when, in the presence of several scientific friends it was put to death under chloroform, and a *post-mortem* examination made. On removing the scalp a fibrous structure, analogous to pericranium, was found, occupying the place from which the bone had been removed, in making the vivisection. Cutting this away, a small amount of fluid escaped, and the cranial cavity thus exposed was found occupied by a white substance resembling the cerebral structure that had been removed six months before. Placing a section of the upper portion of this, which had been stained with hematoxyline, under the microscope, a number of bipolar cells characteristic of the gray structure were observed.

That the bird should have survived such an operation and lived for six months after in the full possession of its faculties, is a remarkable illustration of the recuperative powers of the system. And the regeneration of the parts removed is additional evidence in substantiation of the case reported by Voit.

Unwilling that such an important question should merely rest upon my own observation, I requested the appointment of a committee by the Biological and Microscopical Section to examine the regenerated structure.

The following report on the microscopic characters of the regenerated tissue was prepared by Dr. Carl Seiler, Chairman of the Committee:—

"The specimen handed to me by Dr. J. H. McQuillen appeared to be the medulla, cerebellum, and part of the cerebrum of a bird. Intimately connected with the parts were two tumor-like growths, the one spherical, and of the size of a pea; the other of irregular outline, and smaller than the first.

"A microscopical examination of these growths revealed them to be composed of nerve-tissue, showing longitudinal and transverse

sections of nerve-fibres, and, in some places, multipolar ganglionic cells. The bloodvessels which in the round growth appeared to radiate from a common centre at the base of the growth were filled with oval blood-disks."

This report was accompanied by a section of the brain placed under the microscope, and a micro-photograph, showing the multipolar nerve-cells, prepared by Dr. Seiler.